2023 International Conference on Applied Mathematics and Computer Science (ICAMCS)

8-10 August 2023, Lefkada Island, Greece, eISBN 979-83-50315-24-0

Thermal conductivities determination of synthetic wood with recyclable waste using advanced experimental method and numerical simulation

Loredana JUDELE, Ana-Raluca ROSU, Eduard PROASPAT, Gabriel SANDULACHE, Daniel LEPADATU, Daniel LEPADATU

https://doi.org/10.1109/ICAMCS59110.2023.00037

Abstract

The global economy is at a turning point when the raw material is less and less about demand and harder to obtain. Moreover, the reduction of dioxide emissions carbon is mandatory in the context of climate change. At the same time, the waste in construction and other economic areas is increasingly difficult to manage because its sorting and recycling are not yet in line with the rules imposed by the European community and assumed by each state. In the current context of the need to reduce carbon dioxide emissions more and more, materials used for thermal protection of buildings must be obtained if possible from recyclable materials with low thermal conductivity and minimum energy consumption. In this paper, we propose a comparative analysis of the thermal conductivity obtained experimentally of some synthetic wood boards with variable content of recyclable waste (polystyrene, fly ash, sunflower husks, cement, polymer, etc) using a double-climate chamber, with those obtained by numerical modeling using the finite element method. Experimental planning of synthetic wood boards was carried out with the help of the design of the experiment method which allowed a decrease in the number of experiments necessary for such investigations but with maximum efficiency on the results of the physicomechanical characteristics obtained. The results obtained by the two methods were very conclusive surrounding this material in the category of insulating ones with thermal conductivity between 0.071 and 0.107. We can say that synthetic wood obtained with variable addition of different compatible waste can contribute to more efficient use of this and implicitly to the decrease of the effect on the environment.

Keywords: *finite element method, design of experiment method, recyclable waste, synthetic wood, thermal conductivities*

References:

1. *Interface and bonding mechanisms Industrial Crops and Products, vol. 141, pp. 111788, 2019, [online] Available: https://www.eea.europa.eu/ims/waste-generation-and-decoupling-in-europe. Google Scholar*
2. *A. Nuryawan, NO. Hutauruk, EYS. Purba, N. Masruchin, R. Batubara, I. Risnasari et al., "Properties of wood composite plastics made from predominant Low Density Polyethylene (LDPE) plastics and their degradability inature", PLoSONE, vol. 15, no. 8, pp. e0236406, 2020, [online] Available: https://doi.org/10.1371/journal.pone.0236406. CrossRef Google Scholar*
3. *D.J. Gardner, Y. Han and L. Wang, "Wood–Plastic Composite Technology", Curr Forestry Rep 1, pp. 139-150, 2015, [online] Available: https://doi.org/10.1007/s40725-015-0016-6. CrossRef Google Scholar*
4. *N. Dubey, R. Purohit and R.S. Rana, "Manufacturing of Wood Polymer Composites", Wood Polymer Composites. Composites Science and Technology, 2021, [online] Available: https://doi.org/10.1007/978-981-16-1606-8_2. CrossRef Google Scholar*
5. *Y. Zhou, Y. Wang and M. Fan, Incorporation of tyre rubber into wood plastic composites to develop novel multifunctional composites. CrossRef Google Scholar*
6. *J.E. Winandy, N.M. Stark and C.M. Clemons, "Consideration in recycling of wood plastic composites", 5th Global Wood and Natural Fibre Composites Symposium, April 27–28, 2004. Google Scholar*
7. *S. K. Najafi, "Use of recycled plastics in wood plastic composites – A review", Waste Management, vol. 33, no. 9, pp. 1898-1905, 2013. CrossRef Google Scholar*
8. *J. Lin, T. H. Tan, J. S. Yeo, Y. Goh, T. C. Ling and K. H. Mo, "Municipal woody biomass waste ash-based cold-bonded artificial lightweight aggregate produced by one-part alkali-activation method", Construction and Building Materials, vol. 394, pp. 131619, 2023, [online] Available: https://doi.org/10.1016/j.conbuildmat.2023.131619. CrossRef Google Scholar*
9. *S. Damyanova and V. Dimitrova, "Chemical Composition and Stocks of Nutrients in Dead Wood of Beech (Fagus Sylvatica L.) Forests", WSEAS Transactions on Environment and Development, vol. 19, pp. 465-471, 2023. CrossRef Google Scholar*
10. *A. Keskisaari and T. Kärki, "The use of waste materials in wood-plastic composites and their impact on the profitability of the product", Resources Conservation and Recycling, vol. 134, pp. 257-261, 2018. CrossRef Google Scholar*
11. *Y. Zhou, P. Stanchev, E. Katsou, S. Awad and M. Fan, "A circular economy use of*

recovered sludge cellulose in wood plastic composite production: Recycling and eco-efficiency assessment", Waste Management, vol. 99, pp. 42-48, 2019, [online] Available: https://doi.org/10.1016/j.wasman.2019.08.037. CrossRef Google Scholar

12. *Y. Zhou, Y. Wang and M. Fan, "Incorporation of tyre rubber into wood plastic composites to develop novel multifunctional composites: Interface and bonding mechanisms", Industrial Crops and Products, vol. 141, pp. 111788, 2019, [online] Available: https://doi.org/10.1016/j.indcrop.2019.111788. CrossRef Google Scholar*
13. *E. Kuka, B. Andersons, D. Cirule, I. Andersone, J. Kajaks, H. Militz, et al., "Weathering properties of wood-plastic composites based on heat-treated wood and polypropylene", Composites Part A: Applied Science and Manufacturing, vol. 139, pp. 106102, 2020, [online] Available: https://doi.org/10.1016/j.compositesa.2020.106102. CrossRef Google Scholar*
14. *D. Lepadatu et al., "Particularities of synthetic wood - a biomaterial with recycled waste", Environmental Engineering and Management Journal, vol. 20, no. 4, pp. 585-592, 2021. CrossRef Google Scholar*
15. *H. Nägele et al., "Arboform – A Thermoplastic Processable Material From Lignin and Natural Fibers" in Chemical Modification Properties and Usage of Lignin., Springer, pp. 101-117, 2002. CrossRef Google Scholar*
16. *A. Burkhardt-Karrenbrock, S. Seegmüller and R. Burk, "Liquid wood - A review", Holz als Rohund Werkstoff, vol. 59, pp. 13-18, 2001. Google Scholar*
17. *L. Favier, A.I. Simion, R. M. Hlihor, I. Fekete-Kertész, M. Molnár, M. Harja, et al., "Intensification of the photodegradation efficiency of an emergent water pollutant through process conditions optimization by means of response surface methodology", Journal of Environmental Management, vol. 328, pp. 116928, 2023, [online] Available: https://doi.org/10.1016/j.jenvman.2022.116928. CrossRef Google Scholar*
18. *D.C. Montgomery, Design and Analysis of Experiments, New York, NY, USA:John Wiley & Sons, Inc., 2013. Google Scholar*
19. *G.E.P. Box and N. Draper, Empirical Model Building and Response Surfaces, New York, NY, USA:Wiley, 1987. Google Scholar*
20. *G.E.P. Box, W. Hunter and J.S. Hunter, Statistics for Experimenters, New York, NY, USA:Wiley, 1978. Google Scholar*
21. *D. Lepadatu, L. Judele and I. Antonescu, "Advanced Experimental Design and Optimization Methods for New Building Materials Developed in Civil Engineering" in Sustainable Industrial Processing Summit SIPS2018 New and Advanced Materials and Technologies Montreal, Canada:FLOGEN Star Outreach, vol. 6, pp. 263-286, 2018. Google Scholar*

22. I. Bliuc, D. Lepadatu, A. Iacob, L. Judele and R. D. Bucur, "Assessment of thermal bridges effect on energy performance and condensation risk in buildings using DoE and RSM methods" in Journal European Journal of Environmental and Civil Engineering, Taylor & Francis, vol. 21, no. 12, pp. 1466-1484, 2017. Google Scholar

23. L. Adam, L. Judele, I. Motrescu, I. Rusu, D. Lepadatu and R.D. Bucur, "Advanced Design for Experimental Optimisation of Physico-Mechanical Characteristics of Sustainable Local Hemp Concrete", Sustainability, vol. 15, pp. 8484, 2023, [online] Available: https://doi.org/10.3390/su15118484. CrossRef Google Scholar

24. [online] Available: https://www.feutron.de/en/double-climate-test-chamber/ .

25. M. Pruteanu and M. Vasilache, "Thermal conductivity determination for autoclaved aerated concrete elements used in enclosure masonry walls Buletinul institutului politehnic din iaşi Tomul LIX (LXIII) Fasc. 6", Section Buildinngs and Architecture., pp. 33-42, 2013. Google Scholar

26. [online] Available: https://iut.univ-lemans.fr/ydlogi/rdm_version_7.html.

27. K. Mishra, S. S. Siwal, S. C. Nayaka, Z. Guan and V. K. Thakur, "Waste-to-chemicals: Green solutions for bioeconomy markets", Science of The Total Environment, vol. 887, pp. 164006, 2023, [online] Available: https://doi.org/10.1016/j.scitotenv.2023.164006. CrossRef Google Scholar

28. J. Lin, T. H. Tan, J. S. Yeo, Y. Goh, T. C. Ling and K. H. Mo, "Municipal woody biomass waste ash-based cold-bonded artificial lightweight aggregate produced by one-part alkali-activation method", Construction and Building Materials, vol. 394, pp. 131619, 2023, [online] Available: https://doi.org/10.1016/j.conbuildmat.2023.131619. CrossRef Google Scholar

29. B. Bruma, "Comparative numerical studies on the thermal performance of building envelope elements", Doctoral thesis, 2015. Google Scholar

30. L. Gavrilă, "Fenomene de transfer" in Transfer de căldură și masă., Bacău, Editura, Alma Mater, vol. II, 2000. Google Scholar